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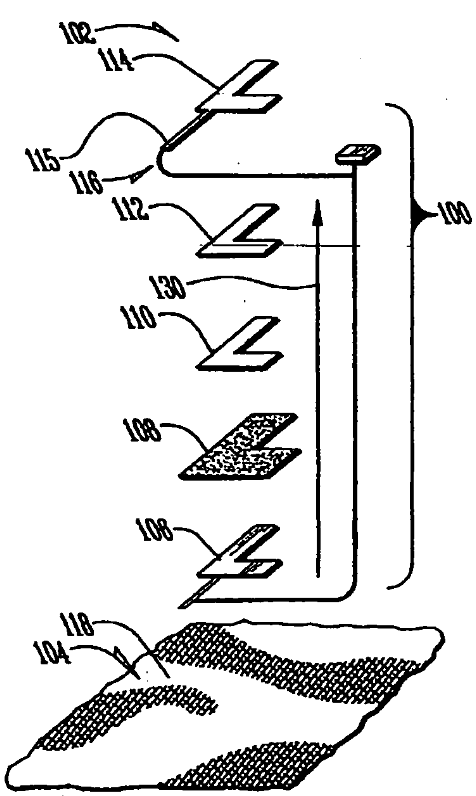
(54) Title: ILLUMINATED DISPLAY SYSTEM AND PROCESS



(57) Abstract: Processes for the integration of illuminated displays with articles of fabric or textiles are described. In one aspect, a rear electrode (106) of an electroluminescent panel (102) is formed directly onto a fabric section substrate (104) by the following process, a formed image is placed over a fabric section to define an area for display and a catalyst is applied to such display area; the fabric section display area with catalyst thereon is immersed in an electroless plating bath and subsequently removed, allowing a chemical reduction to occur in the aqueous solution; such fabric section is immersed in an electrode bath to form an electrode layer integrated with the fabric section and patterned in the associated image. In another aspect, a process is used to form an insulative layer for encapsulating the fabric section substrate having a rear electrode. In still another aspect, process is used to form the layers of an electroluminescent panel integral with a substrate. Optionally, the fabric section can be adhered to a substantially rigid substrate while the EL panel component layers are applied to aid in accurate placement of such layers.

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ILLUMINATED DISPLAY SYSTEM AND PROCESS

RELATED APPLICATIONS

This application is a nonprovisional to U.S. application serial number 60/277,829, filed March 22, 2001, entitled "PROCESS FOR INTEGRATING AN ILLUMINATED DISPLAY WITH FABRIC", which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates generally to applications for using illuminated displays, and more particularly, for integrating electroluminescent light emitting panels with articles of fabric or textiles.

PROBLEM

Electroluminescent (EL) panels or lamps provide illumination for a wide array of objects such as watches, vehicle instrument panels, computer monitors, etc. These EL panels are typically formed by positioning an electroluminescent material, such as phosphor, between two electrodes, one of which is essentially transparent. The electric field created by applying an electric current to the electrodes causes excitation of the electroluminescent material and emission of light therefrom, which is viewed through the transparent electrode. Advancements in materials science have led to the formation of EL panels from thin, elongate, flexible strips of laminated material having a variety of shapes and sizes.

It is desired to have an illuminated display integrated into a fabric or textile application, such that a light source can be created on clothing, backpacks, tents, signs, and the like. However, forming an electroluminescent panel onto fabric presents a particular challenge because of the flexible nature of fabric and the uses to which it is put, such as being worn as an article of clothing. Unlike an EL panel hung on a wall or in a window, electroluminescent panels attached to fabric must be put through repeated cycles of physical stress from flexion of the fabric, and must be properly electrically and thermally insulated due to the increased risk of being touched by a person or worn close to their body. Additionally, fabrics and textiles

have generally proven to be difficult substrates upon which to build the component layers of an EL panel. What is needed is a process for better integrating an EL panel with a fabric section to form a unitary illuminated display system.

Electroluminescent film is commonly used in the display industry as back-lighting for liquid crystal displays. As constructed today, these films are not transparent, or even semi-transparent since the back electrode is either carbon or silver. It is thus also desirable to have a large area illumination source that is semi-transparent, i.e. it allows the observer to see an object through the back-side of the device while it is illuminating the object.

SOLUTION

The present invention involves processes for reliably forming the component layers of an electroluminescent panel onto a fabric section to facilitate construction of the entire EL panel assembly. In one aspect, the layers of an electroluminescent panel are formed integral with a substrate section. First, a rear electrode made of a conductive polymer is formed onto a substrate section in a desired pattern. Then, a dielectric layer is formed over the rear electrode layer. A light emitting layer, transparent conductive layer made of a conductive polymer, and front electrode lead are then successively formed onto the substrate section; the light emitting layer atop the dielectric layer and the transparent conductive polymer layer atop the light emitting layer. Each of the component layers of the EL panel may be formed onto the substrate section by a printing process. Optionally, the substrate section can be adhered to a substantially rigid backing while the EL panel component layers are applied to aid in accurate placement of such layers. This aspect provides a construction where at least the rear electrode is more fully integrated with the substrate section. When an electric current is applied to the front and rear electrodes, an electric field is created to excite the light emitting layer to illuminate.

Another aspect of the present invention provides a process whereby the rear electrode of an EL panel is formed directly onto a fabric section using a metalization process. An image is first formed to define a specific design to be illuminated. The image is placed over a fabric section to define an area for display and a catalyst is applied to such display area. Next, the portion of the fabric section with catalyst

applied thereto is immersed in an electroless plating bath and subsequently removed, which allows a chemical reduction to occur in the aqueous solution. Finally, the fabric section display area is immersed in an electrode bath to form an electrode layer that is integrated with the fabric section and patterned in the associated image. The rest of the layers of the EL panel, including a front electrode, may be formed on top of the rear electrode and base fabric section by, for example, a printing process. Upon energizing the EL panel, a light emitting layer will illuminate in the pattern of the image.

In still another aspect of the present invention, an insulative layer and a process for forming thereof is provided to encapsulate a fabric section having a rear electrode. The fabric section is first immersed in electrophoretic liquid. An electrical lead is connected to the rear electrode and a counter electrode is immersed in the liquid and connected to an electrical lead of opposite polarity. Upon a voltage being applied to the electrical leads, an insulative conformal coating is deposited on the fabric section immersed in the electrophoretic liquid. This coating maintains the integrity of the rear electrode and electrically insulates such electrode, thereby mitigating the risk of electrical shock for a person touching the fabric. Furthermore, the coating may serve as the dielectric layer of the electroluminescent panel. A printing process or other means may be used to form the remaining layers of an EL panel on top of the dielectric layer.

By these processes, safer, more durable illuminated display systems can be manufactured for all types of fabric and textile applications, such as safety clothing (vests, jackets, hats, gloves), outdoor gear (tents, backpacks, etc.), flags and signs, or any other application requiring a flexible illumination solution. Additionally, because the EL panel components of the illuminated display system may be formed together as thin layers by, for example, a printing process, thin EL lamps may be formed that are not too bulky or cumbersome to be worn on an article of clothing. As opposed to reflective strips, the illuminated displays systems formed by these processes do not require light to be reflected off of an EL panel surface from external light sources. Other advantages and components of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings, which constitute a part of this specification and wherein are set forth exemplary

embodiments of the present invention to illustrate various features thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram of an illuminated display system in accordance with an embodiment of the present invention.

Figure 2 is a flowchart illustrating an exemplary process for forming the illuminated display system in accordance with an embodiment of the present invention.

Figure 3 is a flowchart illustrating an exemplary process for performing the metalization of a fabric substrate section in accordance with an embodiment of the present invention.

Figure 4 is a flowchart illustrating an exemplary process forming an insulative layer onto a fabric substrate section in accordance with an embodiment of the present invention.

Figure 5 is a top plan view of the illuminated display system in accordance with an embodiment of the present invention showing a substrate and electroluminescent panel formed thereon.

Figure 6 is a top plan view of a rear electrode formed onto a fabric substrate section system in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a series of processes for forming electroluminescent panel components onto substrates, preferably textiles and fabrics, to create illuminated display systems. In addition, certain components of the display system may be formed together as disclosed in U.S. Patent Serial No. 6,203,391 of Murasko, the teachings of which are incorporated by reference herewith. The '391 patent discloses processes for forming electroluminescent signs by combining electroluminescent lamp components with a sign substrate.

<u>Conductive Polymer Illuminated Display</u>

FIG. 1 presents an aspect of the present invention whereby a conductive polymer is used to form the conductive elements of an electroluminescent panel. This construction serves to better integrate the EL panel with a substrate to form an

illuminated display system 100. Conductive polymers that may be used with EL panel 102 include polyaniline, polypyrrole, and preferably, polyethylene-dioxithiophene, which is available under the trade name "Orgacon" from Agfa Corp. of Ridgefield Park, NJ. Substrate 104 forms the base layer upon which EL panel component layers are formed. Preferably, substrate 104 is a fabric or textile section such that the conductive polymer material can be at least partially absorbed into the fabric fibers, forming a more integral structure. Suitable fabric or textile materials include cotton, nylon, polyester, high-density polyethylene (e.g., Tyvek brand from DuPont Company of Wilmington, DE), and the like. All of these materials are hereinafter referred to as "fabric". EL panel 102 comprises a conductive polymer rear electrode 106, a dielectric layer 108, a light emitting layer 110, a front conductive polymer layer 112, and a front electrode lead 114. Optionally, conductive pads 116 are electrically connected to conductive lead 114 and conductive polymer rear electrode 106 to bring electrical energy to EL panel 102 from a power source to cause light emitting layer 110 to illuminate. Also, front electrode lead 114 is preferably a conductive polymer front outlying electrode lead disposed substantially around the perimeter of front conductive polymer layer 112.

Dielectric layer 108 is formed of a high dielectric constant material, such as barium titanate. Light emitting layer 110 is formed of materials that illuminate upon being positioned in an electric field. Such materials may include non-organics, such as phosphor, or organics such as light emitting polymers, as taught in U.S. Patent Application Serial No. 09/815,078, filed March 22, 2001, for an "Electroluminescent Multiple Segment Display Device", the teachings of which are incorporated by reference herewith. Conductive pads 116 are preferably made of silver, but may be fabricated from any conductive material from which a reliable electrical connector can be formed.

FIG. 2 is a flow chart showing an exemplary sequence of steps for fabricating the electroluminescent panel 102 onto the substrate 104 to form the illuminated display system 100 shown in FIG. 1. Each of the component layers 106-116 of EL panel 102 may be successively applied onto substrate 104 by a variety of means, including stenciling, flat coating, brushing, rolling, and spraying, but preferably are printed onto the substrate by screen or ink jet printing.

If the chosen substrate 104 is made of a flexible material, such as a fabric, substrate 104 is preferably attached to a rigid backing (not shown) using an adhesive before EL panel 102 is built thereon, as shown at step 201. The backing may be of a material such as aluminum, polycarbonate, cardboard, and the like. The adhesive must provide sufficient bonding as to hold substrate 104 in place, but not so strong as to prohibit the removal of the substrate by applying a force to peel the substrate away from the backing. Suitable adhesives for this purpose are contact adhesives such as "Super 77" from 3M Corp. of St. Paul, MN.

At step 202, conductive polymer rear electrode 106 is applied onto a front surface 118 of substrate 104, preferably by printing. Electrode 106 may be applied generally as a sheet layer covering the entire substrate 104, or may be patterned in a specific arrangement on substrate surface 118 to cover only the area desired to be illuminated (i.e. the surface area covered by the light emitting layer 110). Preferably, electrode 106 is made from polyethylene-dioxithiophene, which can be applied by screen printing to form a layer thickness in the range of approximately 0.1 and 50 microns (1 micron = $1x10^{-6}$ meters).

Dielectric layer 108 is then applied onto substrate surface 118 over the rear electrode 106, preferably by printing, at step 203. As an example, dielectric layer 108 comprises a material having a high dielectric constant, such as barium titanate dispersed in a polymeric binder to form a screen printable ink. More than one dielectric layer may be applied to better isolate the rear electrode 106 from other components of the electroluminescent panel 102 and reduce the risk of short circuiting. In addition, if better insulative properties are needed from the dielectric, an insulative coating may be applied over the dielectric layer 108 to further reduce the risk of contact between conductive components of the EL panel 102. As with rear electrode 106, dielectric layer 108 may cover the entire substrate surface or merely the area desired to be illuminated. Preferably, to reduce the risk of short circuiting of the EL panel 102 from the conductive layers 106, 112, 114 coming into contact with one another, dielectric layer 108 is configured to extend outward along the substrate surface 118 beyond the illumination area by approximately 1/16 inches to 1/8 inches. In an exemplary embodiment, dielectric layer 108 may be applied on the substrate surface 118 to have a thickness of between approximately 15 to 40 microns. In an

alternative embodiment, dielectric layer 108 may be omitted from the EL panel 102 if light emitting layer 110 is an organic material, such as light emitting polymer, that exhibits properties of a dielectric material.

At step 204, light emitting layer 110 is applied onto substrate surface 118 over dielectric layer 108, preferably by printing. The surface area dimensions of the layer 110 define the illumination area for the electroluminescent panel 102 (e.g., the letter "L", a logo or icon image, etc.). Light emitting layer 110 may be formed of either organic (i.e. light emitting polymers) or non-organic materials, and preferably is a phosphor layer of electroluminescent particles, e.g., zinc sulfide doped with copper or manganese which are dispersed in a polymeric binder, and having a thickness of about 0.1 to 100 microns. However, the chosen material will depend on the illumination application desired and the power source available to energize the conductors, as light emitting polymers and other organics do not require as high an illumination voltage as non-organic illumination materials.

The conductive polymer chosen for front conductive polymer layer 112 is one that is light-transmissive (i.e. transparent or translucent) such that the illumination provided by light emitting layer 110 may be viewed above electroluminescent panel 102 by an observer. Preferably, the material forming layer 112 is polyethylene-dioxithiophene. At step 205, conductive polymer layer 112 is applied onto substrate surface 118 over light emitting layer 110. Conductive polymer layer 112 extends outward along the substrate surface 118 at least to cover light emitting layer 110, but preferably not beyond the perimeter of dielectric layer 108. In this way, conductive polymer layer 112 works in conjunction with electrode 106 to provide a consistent electric field across the entire surface of the light emitting layer to ensure even illumination of the EL panel 102. Conductive polymer layer 112 preferably has a thickness between about 0.1 to 100 microns, and is preferably applied by printing layer 112. If dielectric layer 108 extends substantially beyond a perimeter of the rear electrode, conductive layer 112 may extend outward along dielectric layer 108 a greater distance than the perimeter of rear electrode 106.

At step 206, front electrode lead 114 is placed into electrical contact with front conductive polymer layer 112 and is configured to transport energy to such layer. In a preferred arrangement, front electrode lead 114 extends substantially or completely

around the perimeter of the conductive polymer layer 112 to ensure that electrical energy is essentially evenly distributed across layer 112. This configuration provides front electrode lead 114 as a front outlying electrode. Optionally, if conductive layer 112 extends beyond the perimeter of rear electrode 106, front electrode lead 114 may be positioned such that it does not substantially overlap the inwardly disposed rear electrode 106. Front electrode lead 114 is typically a 1/16 inch to 1/8 inch wide strip and approximately 2 to 20 percent of the width of conductive polymer layer 112, and may be positioned to directly overlie one or more of the conductive layer 112, dielectric layer 108, or substrate front surface 118. Preferably, front electrode lead 114 is made of a transparent conductive polymer such as polyethylene-dioxithiophene allowing lead 114 to overlap conductive polymer layer 112 and light emitting layer 110 without impeding the viewing of the EL panel illumination. Preferably, lead 114 is printed.

At step 207, conductive pads 116 are electrically connected to front electrode lead 114 and conductive polymer rear electrode 106 to supply electrical energy to EL panel 102 from a power source (not shown). As seen in FIG. 5, conductive pads 116 may be printed onto substrate 104 as lead tails 115 extending to the perimeter of the substrate 104, or may be fabricated as interconnect tabs extending beyond the substrate to facilitate connection to a power source or controller. Preferably, conductive pads 116 are made of silver to provide a reliable electrical conductor.

In a preferred aspect where substrate 104 is a fabric section, the illuminated display system 100 is placed in an oven to cure for 2.5 minutes at approximately 200 degrees Fahrenheit at step 208. This temperature ensures proper curing of the electroluminescent panel 102 components while not distorting or damaging the fibers of the fabric. The system 100 is then removed from the oven.

At step 209, and in the aspect where the substrate is attached to a rigid backing, substrate 104 is then removed from the backing, preferably by peeling substrate 104 away from the backing, to reveal the integrated EL panel 102 and substrate 104 as illuminated display system 100.

Optionally, a background layer or sign substrate (not pictured) having certain transparent and optically opaque areas can be placed over the EL panel as taught in the '391 patent to form a specific illuminated design. The background layer may, for

example, be formed of number of colored printable inks. Further, an insulative protective layer, such as an ultraviolet coating or a urethane layer, may be placed over EL panel 102 and onto the substrate rear surface 120 to reduce the risk of electrical shock from a person coming into contact with conductive elements of the illuminated display system 100.

In accordance with another embodiment, any of conductive polymer rear electrode 106, front conductive polymer layer 112, and front electrode lead 114 may be formed of material other than a conductive polymer so long as at least one of rear electrode 106, conductive layer 112 and lead 114 is made of a conductive polymer. As an example, rear electrode 106 can be made of conductive materials such as silver or carbon particles dispersed in a polymeric ink; conductive layer 112 may be made of transparent conductive materials such as indium-tin-oxide; front electrode lead 114 may be made of the same materials as rear electrode 106, so long as lead 114 does not cover a significant portion of conductive layer 112 and thereby block the light emitted through layer 112.

It has been further determined that the above construction of illuminated display system 100 having all layers fabricated from transparent or translucent conductive polymer produces a device that acts as an electro-optical directional device. Using the arrangement of elements shown in FIG. 1, in an alternative embodiment, a semi-transparent display device 102 is prepared by first applying a conductive polymer film layer to substrate 104 to form rear electrode 106. In this embodiment, substrate may be either a non-fabric material such as polycarbonate film, or a fabric. A dielectric film layer 108 (e.g., barium titanate dispersed in a polymer matrix) is then deposited on top of rear electrode 106, followed by a light emitting film layer 110 and a second layer of conductive polymer film to form front conductive layer 112. In an exemplary embodiment, light emitting layer 110 comprises a phosphor layer of electroluminescent particles, e.g., zinc sulfide doped with copper or manganese which are dispersed in a polymer matrix. Upon application of a voltage (a square wave of approximately 380 volts p-p at approximately 400 HZ) across rear electrode 106 and front conductive layer 112, the device emits light mostly in the direction shown by arrow 130 in FIG. 1.

All layers of transparent or translucent when viewed therethrough in at least

one direction when the EL panel is being powered for illumination. When the display is placed front-side down on a high contrast printed surface (e.g., newsprint, map, etc.), the printed image is clearly visible by an observer looking from the backside of the device through the dielectric. Light is reflected off the surface of the object back through the layer stack to the observer. For example, when a power source is provided to electroluminescent panel 102 to cause light emitting layer 110 to illuminate, items positioned below system 100 when front conductive polymer layer 112 is positioned face down on such items are illuminated and viewable through EL panel 102. Conversely, when front conductive polymer layer 112 is positioned face up in relation to the item located directly below substrate 104, system 100 is optically opaque, preventing the viewing of the item through EL panel 102. The present method is suitable for fabricating devices that are screen printed onto non-fabric materials such as polycarbonate film, as well as fabric sections. This type of illumination method may also be used as a light source for E-ink or other electrochromic display devices with high contrast.

FIG. 3 shows the process steps to perform the metalization of a fabric substrate section. Once the metalization process is complete, thereby forming a rear electrode of an electroluminescent panel, the remaining EL panel components can the be built onto the metalized fabric section to form an illuminated display system. Suitable metals for use in the metalization process are those that serve as both good electrodes and also have the capability of being coated onto fabrics using standard electroless plating procedures. Examples of metals that are suitable for this process include copper, nickel, and other metals exhibiting similar characteristics. The use of fabrics as substrates upon which the rear electrode and other EL panel components are formed allows the rear electrode to efficiently bond to the fabric fibers, forming a more integral structure. Suitable fabric or textile materials include cotton, nylon (e.g., rip-stop), polyester, high-density polyethylene (e.g., Tyvek brand from DuPont Company of Wilmington, DE), and the like. The metalization process employs the use of an electroless plating bath and a conductor bath to form a thin, flexible, conductive electrode in a defined shape integrated with a section of fabric.

In accordance with one embodiment, an image, such as a word, logo, icon, etc., is generated on a film transparency at step 301. This image corresponds to the

area desired to be illuminated by an electroluminescent panel. The transparency chosen should be one that may be used by a printing device to burn the image into a photographic emulsion and may include transparencies made from plastics, polycarbonates, and similar materials. As an example, the image may be generated on the transparency using a computer graphics program.

At step 302, the film transparency with the image thereon is burned into a photographic emulsion, so that the image may be used with a printing device, such as a screen printer.

At step 303, the printing device is positioned over the fabric section and a catalyst solution is applied to a surface of the fabric. In this way, the catalyst solution will be positioned on the fabric section in the shape of the desired image. It should be noted that steps 301 and 302 may be omitted if a device besides a printing device is used to apply the catalyst solution to the fabric in the shape of the image.

The fabric section with catalyst thereon is then immersed in an electroless plating bath at step 304. This step allows a chemical reduction to occur in the bath. It is not necessary for the entire fabric section to be immersed in the bath, merely the portion of fabric section with the catalyst. The fabric section is then subsequently removed and allowed to dry.

At step 305, the fabric section and applied catalyst are immersed in an electrode bath, preferably an aqueous solution containing metallic particles such as copper, nickel, or other metals exhibiting similar conductive characteristics. The metallic particles then migrate through the bath to the catalyst, depositing on the fabric surface in the shape of the image. As with the electroless plating bath, it is only necessary to immerse the portion of fabric section with the catalyst into the electrode bath. The fabric section then subsequently removed and allowed to dry.

As a result of these process steps, a fabric section is formed with a rear electrode thereon that is electrically conductive in the pattern of the image (i.e. in the desired illumination area). The rear electrode formed from this process typically has a thickness of between approximately 0.1 and 100 microns. The remaining layers of an electroluminescent panel, including the dielectric layer, the light emitting layer, the transparent conductive layer, and the front electrode lead, may be formed onto the rear electrode as discussed in steps 203-207 of FIG. 2 regarding the conductive

polymer illuminated display. Additionally, the transparent conductive layer and front electrode layer may be made of either conductive polymers, or inorganics, such as indium-tin-oxide for the transparent conductive layer and silver or carbon particles dispersed in a polymeric binder for the front electrode lead. In addition, an insulative protective layer, such as an ultraviolet coating or a urethane layer, may be placed over EL panel components and onto the fabric substrate rear surface 120 to reduce the risk of electrical shock from a person coming into contact with conductive elements of the illuminated display system 100. When an electric potential is applied across the rear electrode and the front electrode lead, the light emitting layer will illuminate in the pattern of the image formed by the rear electrode. The rear electrode produced by this process is pliable and can be applied to fabric more easily that a typical silver or carbon electrode. Thus, such a rear electrode design will prolong the life of an EL panel system attached to an article of fabric.

Insulative Layer Formation

Subsequent to performing the process for the metalization of a fabric substrate section, an insulative layer may be applied to the fabric substrate section to encapsulate the fabric, providing uniform insulation and reducing the risk of electric shock or short circuit of an electroluminescent panel formed onto the fabric section. However, it is to be understood that the insulative layer formation process may be used with fabric section having rear electrode formed thereon by a process other than the fabric metalization process described above. Once the insulative layer is formed onto the fabric section, it serves as a dielectric layer, allowing the remaining EL panel components to be built thereon to form an illuminated display system. Suitable fabric materials for this process include cotton, nylon (e.g., rip-stop), polyester, high-density polyethylene (e.g., Tyvek brand from DuPont Company of Wilmington, DE), and the like. The process steps for forming the insulative layer are shown in FIG. 4.

At step 401, the fabric section having the rear electrode formed thereon is immersed in a vessel containing electrophoretic liquid. If desired, the entire fabric section may be immersed in the electrophoretic liquid to form an insulative layer over the entire fabric section, not merely the portion where the rear electrode is located. However, as shown in FIG. 6, a small area of a lead tail 115 of the rear electrode 106,

preferably about 0.25 inches in length and width, should be covered so as to avoid exposure to the electrophoretic liquid to enable a conductive pad 116 to be attached thereto to bring electrical energy to the rear electrode 106.

A counter electrode is positioned in the electrophoretic liquid adjacent to the fabric section at step 402. The counter electrode can be made of any conductive material, e.g., a metal such as copper or nickel. In this way, the electrophoretic liquid vessel has two electrodes positioned therein: the rear electrode of the fabric section and the counter electrode.

At step 403, a voltage source, such as a DC power supply (or a battery), is attached to the fabric section rear electrode and the counter electrode. A first lead of one polarity (i.e. positive or negative) electrically connects the voltage source to the rear electrode and a second lead of opposite polarity of the first lead electrically connects the voltage source to the counter electrode. The first lead preferably connects to the area of the lead tail 115 that is covered from exposure to the electrophoretic liquid.

At step 404, the voltage source creates a potential difference between the fabric section rear electrode and the counter electrode, causing the flow of electrical energy through the electrophoretic liquid. This process causes an insulative conformal coating to deposit onto at least the rear electrode of the fabric section, and preferably, onto the entire fabric section that is immersed in the electrophoretic liquid. The insulative coating will typically be formed onto the fabric section at a thickness between approximately 0.1 and 100 microns.

At step 405, the fabric section is removed from the electrophoretic liquid, and then rinsed and allowed to dry. Optionally, an insulating protective layer, such as an ultraviolet coating or a urethane layer, may be formed on both sides of the fabric over areas having a metal coating or conductor to protect persons who touch the fabric from electrical shock.

The insulative conformal coating provides a number of benefits in forming an electroluminescent panel onto a fabric section. First, the coating maintains the integrity of the rear electrode and electrically insulates such electrode on both the front and rear surfaces of the fabric section, thereby mitigating the risk of electrical shock for a person touching the fabric. Also, the coating may encapsulate the entire

fabric section immersed in the electrophoretic liquid, thereby providing uniform insulation to eliminate short circuiting from other conductive elements of an EL panel formed onto the fabric. Furthermore, the process shortens the manufacturing of an EL panel in that the insulating barrier can serve as a dielectric layer, whereby the light emitting layer, the transparent conductive layer, and the front electrode lead are applied thereon as discussed in steps 204-207 of FIG. 2 regarding the conductive polymer illuminated display. Additionally, and as with the metallized fabric process, the transparent conductive layer and front electrode layer may be made of either conductive polymers, or inorganics, such as indium-tin-oxide for the transparent conductor and silver or carbon particles dispersed in a polymeric binder for the front electrode lead. When an electric potential is applied across the rear electrode and the front electrode lead, the light emitting layer will illuminate in the pattern of the image formed by the rear electrode.

The invention thus attains the objects set forth above, among those apparent from preceding description. Since certain changes may be made in the above systems and methods without departing from the scope of the invention, it is intended that all matter contained in the above description be interpreted as illustrative and not in a limiting sense.

CLAIMS

What is claimed is:

1. An Illuminated display integrated with a fabric substrate, comprising:
a rear electrode formed on a portion of a front surface of the fabric substrate;
a dielectric layer formed onto the fabric substrate surface substantially over the rear electrode;
a light emitting layer formed onto the dielectric layer;
a transparent conductive layer formed onto the light emitting layer; and
a front electrode lead electrically connected to the transparent conductive layer to transport energy thereto.

2. The illuminated display of claim 1, wherein the dielectric layer is an insulative conformal coating formed by application of a voltage to electrophoretic liquid surrounding the fabric substrate.

3. The illuminated display of claim 1, wherein the rear electrode is formed on the fabric substrate portion by applying a catalyst to the fabric portion and subsequently immersing the fabric portion in an electroless plating bath followed by immersing the fabric portion in an electrode bath.

4. The illuminated display of claim 3, wherein the rear electrode is formed substantially only where the catalyst was applied to the fabric substrate portion.

5. The illuminated display of claim 1, wherein the dielectric layer covers the entire rear electrode except for a portion of a lead tail of the rear electrode.

6. The illuminated display of claim 1, including an insulative layer formed onto a portion of a back surface of the substrate opposite of the rear electrode.

7. The illuminated display of claim 1, including an insulative layer formed onto the front surface and a back surface of the substrate.

8. The illuminated display of claim 1, wherein the light emitting layer is a phosphor layer.

9. The illuminated display of claim 1, wherein the light emitting layer is a light emitting polymer layer.

10. The illuminated display of claim 1, wherein the fabric substrate is made from materials comprising at least one material selected from the group consisting of cotton, polyester, nylon, and high-density polyethylene.

11. The illuminated display of claim 1, wherein the front electrode lead is a front outlying electrode layer substantially surrounding a perimeter of the transparent conductive layer.

12. The illuminated display of claim 1, wherein the transparent conductive layer extends outward along the fabric substrate substantially beyond a perimeter of the rear electrode, and the front electrode lead is disposed substantially at a perimeter of the transparent conductive layer such that the rear electrode and front electrode lead substantially do not overlap.

13. The illuminated display of claim 1, wherein the transparent conductive layer is an indium-tin-oxide layer.

14. The illuminated display of claim 1, wherein the rear electrode is formed as a layer containing a catalyst and at least one material selected from the group consisting of copper and nickel.

15. The illuminated display of claim 1, wherein the fabric substrate is an article of clothing.

16. The illuminated display of claim 1, wherein the light emitting layer is screen printed onto the at least one dielectric layer.

17. The illuminated display of claim 1, wherein the transparent conductive layer is screen printed onto the light emitting layer.

18. A method for integrating an illuminated display with a fabric substrate, comprising:

coating a portion of a front surface of the fabric substrate with a rear electrode;

forming a dielectric layer onto over the rear electrode;
forming a light emitting layer onto the dielectric layer;
forming an transparent conductive layer onto the light emitting layer; and
electrically connecting a front electrode lead to the transparent electrode layer to transport energy to the transparent conductive layer.

19. The method of claim 18, further comprising the step of electrically connecting a power source to the rear electrode and the front electrode lead to illuminate the light emitting layer.

20. The method of claim 18, wherein the step of coating a portion of the fabric substrate with a rear electrode comprises applying a catalyst to a portion of the substrate and subsequently immersing the portion of the substrate in an electroless plating bath followed by immersing the substrate portion in an electrode bath.

21. The method of claim 20, wherein the rear electrode is formed substantially only where the catalyst was applied to the fabric substrate portion.

22. The method of claim 20, wherein the catalyst is screen printed onto the portion of the fabric substrate.

23. The method of claim 20, wherein the electrode bath is an electrode bath selected from the group consisting of a copper or nickel bath.

24. The method of claim 18, including the step of forming an insulative layer onto a portion of a back surface of the substrate opposite of the rear electrode.

25. The method of claim 18, including the step of forming an insulative layer onto the front surface and a back surface of the substrate.

26. The method of claim 18, wherein the step of forming a light emitting layer comprises forming a phosphor layer onto the dielectric layer.

27. The method of claim 18, wherein the step of forming a light emitting layer comprises forming a light emitting polymer layer onto the dielectric layer.

28. The method of claim 18, wherein the step of electrically connecting a front electrode lead to the transparent conductive layer comprises positioning the lead to substantially surround and contact a perimeter of the transparent conductive layer.

29. The method of claim 18, wherein the step of forming a transparent conductive layer onto the light emitting layer comprises forming the transparent conductive layer to extend outward along the fabric substrate substantially beyond a perimeter of the rear electrode, and the step of connecting a front electrode lead to the transparent conductive layer comprises positioning the lead substantially at a perimeter of the transparent conductive layer such that the rear electrode and front electrode lead do not overlap substantially.

30. The method of claim 18, wherein the step of forming a light emitting layer onto the at least one dielectric layer comprises printing the light emitting layer onto the dielectric layer.

31. The method of claim 18, wherein the step of forming a transparent conductive layer onto the light emitting layer comprises printing the transparent conductive layer onto the light emitting layer.

32. A method for forming an electrode layer onto fabric substrate, comprising:

placing an image over a fabric substrate to define a display area;

applying a catalyst to the display area;

immersing the fabric substrate with the display area in an electroless plating bath; and

immersing the fabric substrate with the display area in a conductor bath;

wherein the electrode layer is formed onto the display area of the fabric substrate.

33. The method of claim 32, further comprising:

forming the image on a transparency;

burning the image on the transparency into a photographic emulsion; and

wherein the step of placing an image over the fabric substrate comprises placing the screen printing device with the photographic emulsion over a fabric substrate to define the display area.

34. The method of claim 32, wherein the step of immersing the fabric substrate with the display area in a conductor bath comprises immersing the fabric substrate with display area in a conductor bath selected from the group consisting of a copper or nickel bath.

35. The method of claim 32, wherein the fabric substrate is made from materials comprising at least one material selected from the group consisting of cotton, polyester, nylon, and high-density polyethylene. .

36. A method for forming an insulative conformal coating around an electrically conductive fabric substrate, comprising:

placing the fabric substrate in electrophoretic liquid;

placing a counter electrode in the electrophoretic liquid;

applying a voltage to the substrate and the counter electrode; and

wherein the insulative conformal coating is formed around the substrate.

37. The method of claim 36, wherein the fabric substrate is made from materials comprising at least one material selected from the group consisting of cotton, polyester, nylon, and high-density polyethylene.

38. An integrated illuminated display and substrate, comprising:

a substrate section;

a conductive polymer rear electrode layer formed onto the substrate section;

a dielectric layer formed onto the conductive polymer rear electrode layer;

a light emitting layer formed onto the dielectric layer;

a front conductive polymer layer formed onto the light emitting layer; and

a front electrode lead connected to the front conductive polymer layer.

39. The display of claim 38, wherein:

the conductive polymer rear electrode layer is printed onto the substrate section;

the dielectric layer is printed onto the conductive polymer rear electrode layer;
the light emitting layer is printed onto the dielectric layer; and
the front conductive polymer layer is printed onto the light emitting layer.

40. The display of claim 38, further comprising two or more conductive pads, one of the pads electrically connected to the front electrode lead and another one of the pads electrically connected to the conductive polymer rear electrode layer to provide electrical contacts for a power source.

41. The display of claim 38, wherein the front conductive polymer layer is substantially transparent.

42. The display of claim 38, wherein the substrate section is a textile section.

43. The display of claim 42, wherein the textile section is made from materials comprising at least one material selected from the group consisting of cotton, polyester, nylon, and high-density polyethylene.

44. The display of claim 38, wherein the light emitting layer is a phosphor layer.

45. The display of claim 38, wherein the light emitting layer is a light emitting polymer layer.

46. The display of claim 38, wherein the front electrode lead is a conductive polymer front outlying electrode layer substantially surrounding a perimeter of the transparent conductive polymer layer.

47. The display of claim 38, wherein the front electrode lead is formed directly onto at least one of the substrate section, the dielectric layer, and the front conductive polymer layer.

48. The display of claim 38, wherein the conductive polymer is polyethylene-dioxithiophene.

49. A method for forming an integrated illuminated display and substrate section, comprising:

forming a conductive polymer rear electrode layer onto the substrate section;

forming a dielectric layer onto the conductive polymer rear electrode layer;

forming a light emitting layer onto the dielectric layer;

forming a front conductive polymer layer onto the light emitting layer; and

connecting a front electrode lead to the transparent conductive polymer layer.

50. The method of claim 49, further comprising:

attaching the substrate section to a substantially rigid backing using an adhesive prior to the forming of the conductive polymer rear electrode layer onto the substrate section; and

detaching the substrate section from the substantially rigid backing subsequent to the forming of the front conductive polymer layer onto the light emitting layer.

51. The method of claim 49, further comprising forming the front electrode lead onto either the substrate section or at least one layer selected from the group consisting of the dielectric layer and the front conductive polymer layer, to substantially surround a perimeter of the front conductive polymer layer.

52. The method of claim 49, further comprising electrically connecting a first conductive pad to the front electrode lead and electrically connecting a second conductive pad to the conductive polymer rear electrode layer to provide electrical contacts for a power source.

53. The method of claim 49, wherein:

the step of forming a conductive polymer rear electrode layer comprises printing a conductive polymer rear electrode layer onto the substrate section;

the step of forming a dielectric layer comprises printing a dielectric layer onto the conductive polymer rear electrode layer;

the step of forming a light emitting layer comprises printing a light emitting layer onto the dielectric layer; and

the step of forming a front conductive polymer layer comprises printing a front conductive polymer layer onto the light emitting layer.

54. The method of claim 49, wherein the substrate section is a textile section.

55. The method of claim 54, wherein the textile section is made from materials comprising at least one material selected from the group consisting of cotton, polyester, nylon, and high-density polyethylene.

56. The method of claim 49, wherein the step of forming a light emitting layer comprises forming a phosphor layer onto the dielectric layer.

57. The method of claim 49, wherein the step of forming a light emitting layer comprises forming a light emitting polymer layer onto the dielectric layer.

58. The method of claim 49, wherein the conductive polymer is polyethylene-dioxithiophene.

59. The method of claim 49, wherein the front conductive polymer layer is transparent.

60. A method for forming an integrated illuminated display and substrate, comprising:

attaching a substrate section to a substantially rigid backing using an adhesive;
forming a rear electrode layer onto the substrate section;
forming a dielectric layer onto the rear electrode layer;
forming a light emitting layer onto the dielectric layer;
forming a front conductive layer onto the light emitting layer;
connecting a front electrode lead to the transparent front electrode layer to transport energy to the transparent electrode layer; and
detaching the substrate section from the substantially rigid backing.

61. The method of claim 60, wherein the rear electrode layer, the front conductive layer, and the front electrode lead are comprised of conductive polymer.

62. The method of claim 61, wherein the conductive polymer is polyethylene-dioxithiophene.

63. The method of claim 60, further comprising forming the front electrode lead onto either the substrate section or at least one layer selected from the group consisting of the dielectric layer and the front conductive layer, to substantially surround a perimeter of the front conductive layer.

64. The method of claim 60, wherein:

the step of forming a rear electrode layer comprises printing a rear electrode layer onto the substrate section;

the step of forming a dielectric layer comprises printing a dielectric layer onto the rear electrode layer;

the step of forming a light emitting layer comprises printing a light emitting layer onto the dielectric layer; and

the step of forming a front conductive layer comprises printing a front conductive layer onto the light emitting layer.

65. The method of claim 60, wherein the substrate section is a textile section.

66. The method of claim 65, wherein the textile section is made from materials comprising at least one material selected from the group consisting of cotton, polyester, nylon, and high-density polyethylene.

67. The method of claim 60, wherein the step of forming a light emitting layer comprises forming a phosphor layer onto the dielectric layer.

68. The method of claim 60, wherein the step of forming a light emitting layer comprises forming a light emitting polymer layer onto the dielectric layer.

69. The method of claim 60, wherein the front conductive layer is transparent.

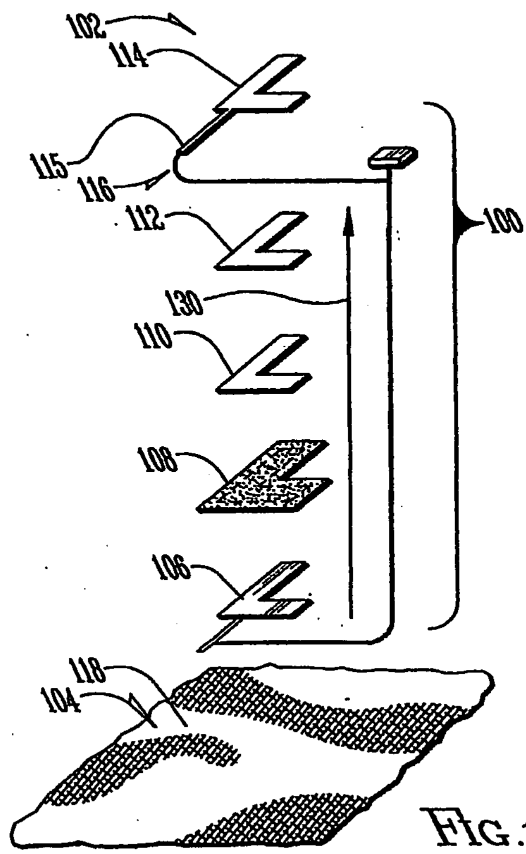

FIG. 1

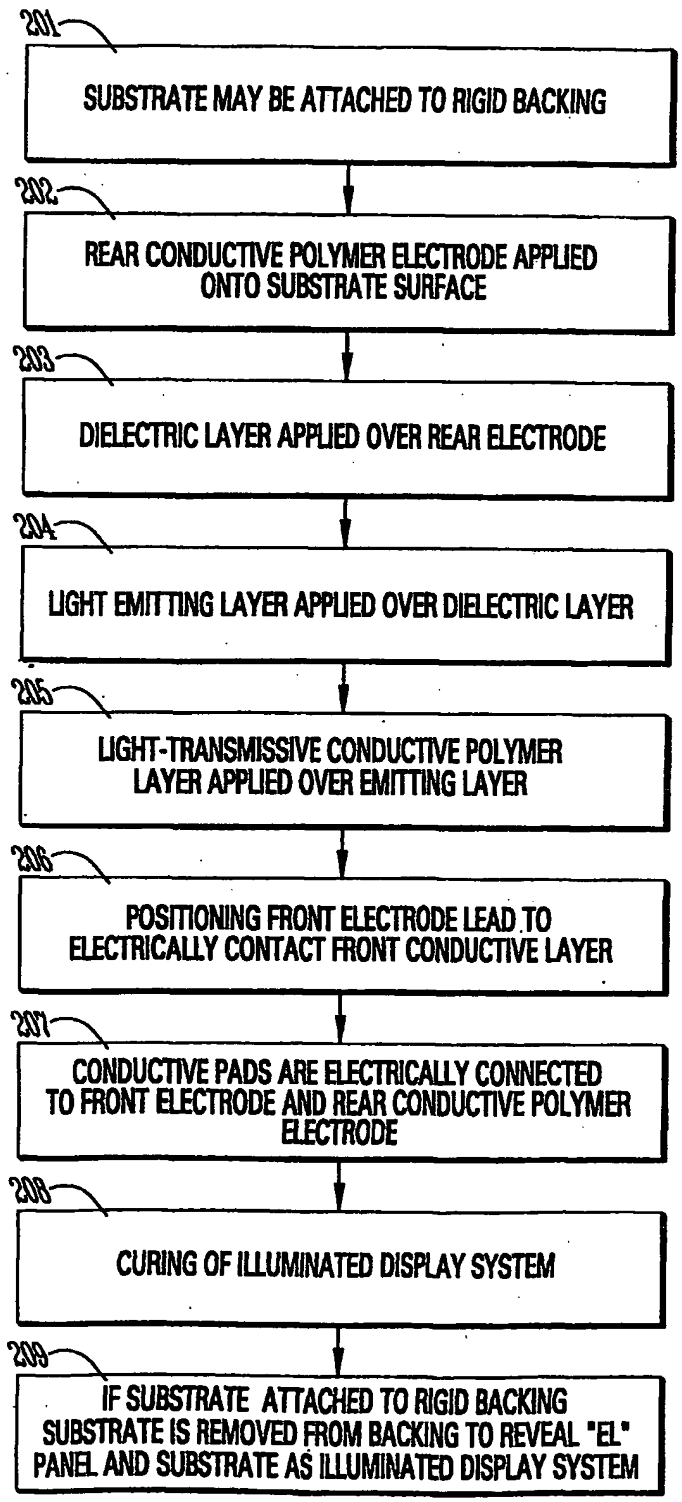
201
SUBSTRATE MAY BE ATTACHED TO RIGID BACKING
202
REAR CONDUCTIVE POLYMER ELECTRODE APPLIED ONTO SUBSTRATE SURFACE
203
DIELECTRIC LAYER APPLIED OVER REAR ELECTRODE
204
LIGHT EMITTING LAYER APPLIED OVER DIELECTRIC LAYER
205
LIGHT-TRANSMISSIVE CONDUCTIVE POLYMER LAYER APPLIED OVER EMITTING LAYER
206
POSITIONING FRONT ELECTRODE LEAD TO ELECTRICALLY CONTACT FRONT CONDUCTIVE LAYER
207
CONDUCTIVE PADS ARE ELECTRICALLY CONNECTED TO FRONT ELECTRODE AND REAR CONDUCTIVE POLYMER ELECTRODE
208
CURING OF ILLUMINATED DISPLAY SYSTEM
209
IF SUBSTRATE ATTACHED TO RIGID BACKING SUBSTRATE IS REMOVED FROM BACKING TO REVEAL "EL" PANEL AND SUBSTRATE AS ILLUMINATED DISPLAY SYSTEM

FIG. 2

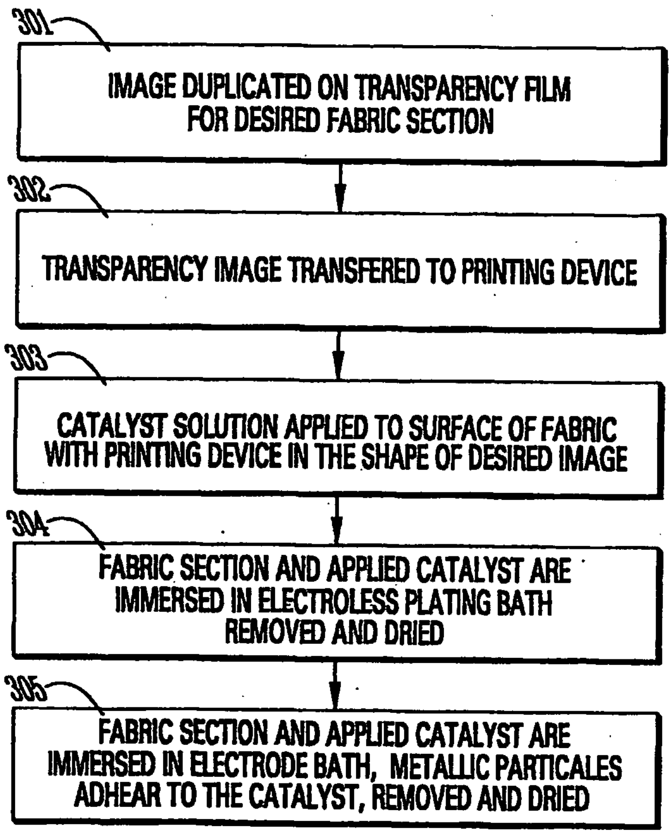
301
IMAGE DUPLICATED ON TRANSPARENCY FILM FOR DESIRED FABRIC SECTION
302
TRANSPARENCY IMAGE TRANSFERED TO PRINTING DEVICE
303
CATALYST SOLUTION APPLIED TO SURFACE OF FABRIC WITH PRINTING DEVICE IN THE SHAPE OF DESIRED IMAGE
304
FABRIC SECTION AND APPLIED CATALYST ARE IMMERSED IN ELECTROLESS PLATING BATH REMOVED AND DRIED
305
FABRIC SECTION AND APPLIED CATALYST ARE IMMERSED IN ELECTRODE BATH, METALLIC PARTICALES ADHEAR TO THE CATALYST, REMOVED AND DRIED

FIG.3

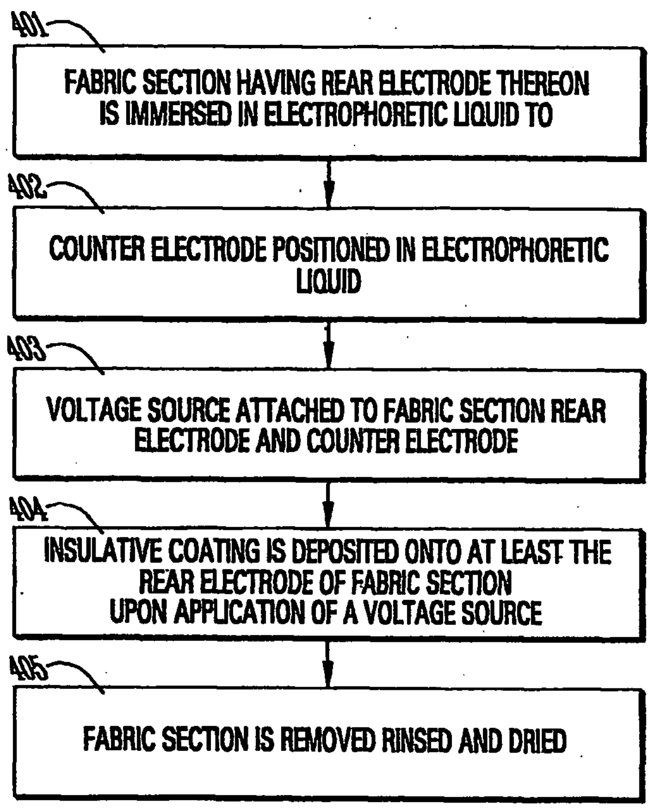
401
FABRIC SECTION HAVING REAR ELECTRODE THEREON IS IMMERSED IN ELECTROPHORETIC LIQUID TO
402
COUNTER ELECTRODE POSITIONED IN ELECTROPHORETIC LIQUID
403
VOLTAGE SOURCE ATTACHED TO FABRIC SECTION REAR ELECTRODE AND COUNTER ELECTRODE
404
INSULATIVE COATING IS DEPOSITED ONTO AT LEAST THE REAR ELECTRODE OF FABRIC SECTION UPON APPLICATION OF A VOLTAGE SOURCE
405
FABRIC SECTION IS REMOVED RINSED AND DRIED

FIG. 4

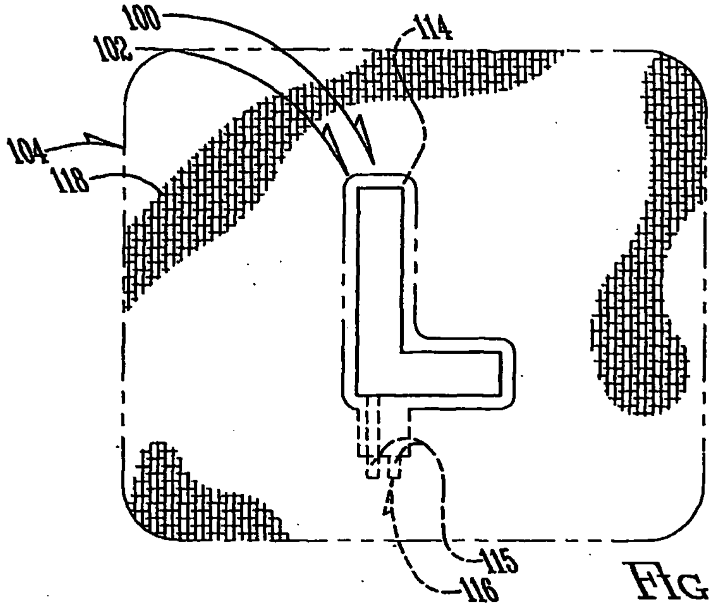

FIG.5

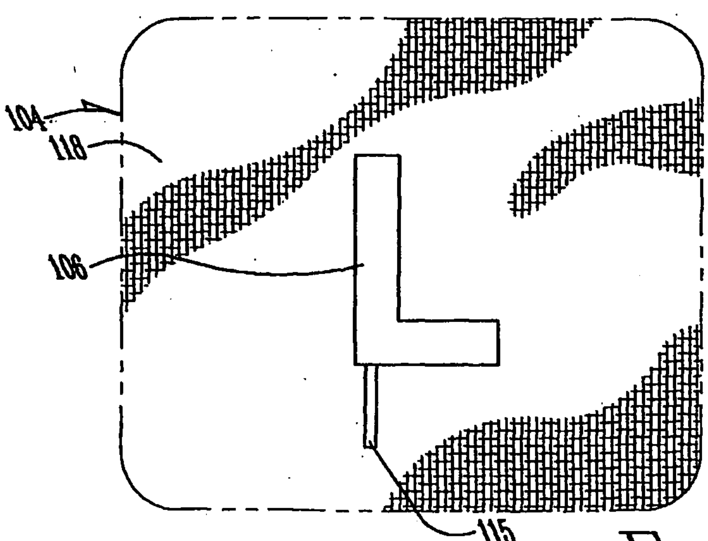

FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/09013

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H01J 1/62
US CL : 313/498, 506, 509, 512; 445/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 313/498, 506, 509, 512; 445/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,856,029 A (BURROWS) 05 January 1999 (05.01.1999), enitre document	1-5, 8, 10-19, 28-31, 38-44, 46, 47, 49, 51-56, 59, --- 7, 9, 24, 25, 27, 45, 50, 57, 60-69
Y	US 5,663,573 A (EPSTEIN et al.) 02 September 1997 (02.09.1997), column 6, lines 1-51	9, 27, 45,
Y	US 5,856,030 A (BURROWS) 05 Januay 1999 (05.01.1999), entire document	50, 60-69
Y --- A	US 6,203,391 B1 (MURASKO) 20 Mach 2001 (20.03.2001) entire document	60-69 --- 20-23, 32-37, 48, 58,

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 23 July 2002 (23.07.2002)	Date of mailing of the international search report 08 AUG 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Nimeshkumar D. Patel Telephone No. (703) 308-0956

Form PCT/ISA/210 (second sheet) (July 1998)